What is claimed is:

1. A method for functionalizing a collection of carbon nanotubes (CNTs), the method comprising:

irradiating a precursor gas at a selected production location to provide a plurality of particles of a selected target species in a first chamber having a first selected sub-Torr chamber pressure p1, where at least one non-target species is also present in the first chamber;

providing a collection of CNTs on a substrate in a second chamber having a second selected sub-Torr pressure p2, where p2 is not more than about p1/100;

providing a particle communication mechanism, having a particle aperture entrance, that allows transport of at least a portion of the particles from the first chamber to the second chamber, where the aperture entrance is spaced apart by a selected distance from the production location, and the selected distance is approximately equal to a distance value (i) that is no greater than a product of a representative particle velocity and an estimated lifetime for a target species particle and (ii) that is much greater than a product of a representative particle velocity and an estimated lifetime for at least one non-target species particle; and

allowing at least one of the target species particles to become chemically attached to at least one of the CNTs in the second chamber,

whereby a density of the at least one non-target species adjacent to the aperture entrance is reduced relative to a density of the target species adjacent to the aperture entrance.

2. The method of claim 1, further comprising configuring said particle communication mechanism so that transport of ultraviolet radiation from said first chamber to said second chamber is suppressed.

3. The method of claim 2, wherein said transport of said ultraviolet radiation from said first chamber to said second chamber is suppressed by providing an

elongated aperture, having an aperture central axis and an aperture side wall and connecting said first and second chambers, further comprising arranging the aperture according to at least one of the following: (i) the aperture central axis is aligned off-axis so that little or no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, (ii) the aperture central axis is curvilinear, and is provided with sufficient curvature so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, and (iii) the aperture central axis has at least one bend point at which a direction of the central axis changes abruptly so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber.

4 The method of claim 3, further comprising providing at least a portion of said aperture side wall with a chemical substance (i) that absorbs said ultraviolet radiation and emits no radiation in response thereto or (ii) that absorbs said ultraviolet radiation and, in response thereto, emits radiation having an emitted energy that is lower than required to cause a bond breakage in at least one of a carbon-carbon bond and a carbon-hydrogen bond.

5. The method of claim 1, further comprising choosing the target particles from a group of target particle species consisting of H, Li, Na, K, Rb, Cs, F, Cl, Br, I, dichlorocarbene, C_nH_{2n}, C_nH_{2n+1} and C_nH_{2n+2}, with n = 1, 2 and 3.

6. The method of claim 1, wherein said step of irradiating said precursor gas comprises irradiating said precursor gas with at least one of a dc source, a radiofrequency source, a microwave source and an induction source of radiation to provide a cold plasma.

7. The method of claim 1, further comprising choosing said pressure p1 in a range 100 μm Hg $\leq$ p1 $\leq$ 1000 μm Hg.

8. The method of claim 1, further comprising choosing said pressure p2 in a range 1 μm Hg $\leq$ p2 $\leq$ 10 μm Hg.

9. The method of claim 1, further comprising allowing at least one of said target particles to become chemically attached to at least one of said CNTs in said second chamber in an exposure time interval no longer than about 30 sec.

10. The method of claim 1, further comprising allowing said at least one target particle to become chemically attached to said at least one CNT at a temperature in said second chamber that is no greater than about room temperature.

11. A system for functionalizing a collection of carbon nanotubes (CNTs), the system comprising:

a first chamber having a plurality of precursor particles at a first selected sub-Torr pressure p1 at a selected production location, where at least one non-target species is also present in the first chamber;

a radiation source for irradiating the precursor gas to provide a plurality of selected target species particles;

a substrate, located in a second chamber and having a collection of CNTs thereon, where the second chamber has a second selected sub-Torr pressure p2 and where p2 is not more than about p1/100; and

a particle communication mechanism, having a particle aperture entrance, that allows transport of at least a portion of the target species particles from the first chamber to the second chamber, where the aperture entrance is spaced apart by a selected distance from the production location, and the selected distance is approximately equal to a distance value (i) that is no greater than a product of a

representative particle velocity and an estimated lifetime for a target species particle and (ii) that is much greater than a product of a representative particle velocity and an estimated lifetime for at least one non-target species particle;

whereby at least one of the target particles becomes chemically attached to at least one of the CNTs in the second chamber, and a density of the at least one non-target species adjacent to the aperture entrance is reduced relative to a density of the target species adjacent to the aperture entrance.

12. The system of claim 11, wherein said particle communication mechanism is configured so that transport of ultraviolet radiation from said first chamber to said second chamber is suppressed.

13. The system of claim 12, wherein said transport of said ultraviolet radiation from said first chamber to said second chamber is suppressed by providing an elongated aperture, having an aperture central axis and an aperture side wall and connecting said first and second chambers, and the aperture is configured according to at least one of the following: (i) the aperture central axis is aligned off-axis so that little or no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, (ii) the aperture central axis is curvilinear, and is provided with sufficient curvature so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, and (iii) the aperture central axis has at least one bend point at which a direction of the central axis changes abruptly so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber.

14 The system of claim 13, wherein at least a portion of said aperture side wall is provided with a chemical substance (i) that absorbs said ultraviolet radiation and emits no radiation in response thereto or (ii) that absorbs said ultraviolet

radiation and, in response thereto, emits radiation having an emitted energy that is lower than required to cause a bond breakage in at least one of a carbon-carbon bond and a carbon-hydrogen bond.

15. The system of claim 11, wherein said target particles are chosen from a group of target particle species consisting of H, Li, Na, K, Rb, Cs, F, Cl, Br, I, dichlorocarbene, C_nH_{2n}, C_nH_{2n+1} and C_nH_{2n+2}, with n = 1, 2 and 3.

16. The system of claim 11, wherein said radiation source for irradiating said precursor gas is at least one of a dc source, a radiofrequency source, a microwave source and an induction source of radiation to provide a cold plasma.

17. The system of claim 11, wherein said pressure p1 lies in a range 100 μm Hg $\leq$ p1 $\leq$ 1000 μm Hg.

18. The system of claim 11, wherein said pressure p2 lies in a range 1 μm Hg $\leq$ p2 $\leq$ 10 μm Hg.

19. The system of claim 11, wherein at least one of said target particles becomes chemically attached to at least one of said CNTs in said second chamber in an exposure time interval no longer than about 30 sec.

20. The system of claim 11, where said at least one target particle becomes chemically attached to said at least one CNT at a temperature in said second chamber that is no greater than about room temperature.

21. A method for functionalizing a collection of carbon nanotubes (CNTs), the method comprising:

irradiating a precursor gas at a selected production location to provide a plurality of particles of a selected charged particle target species in a first chamber

having a first selected sub-Torr chamber pressure p1, and to provide a preferred initial velocity for at least one target species particle, where at least one charged non-target species particle is also present in the first chamber;

providing a collection of CNTs on a substrate in a second chamber having a second selected sub-Torr pressure p2, where p2 is not more than about p1/100;

providing a particle communication mechanism, having a particle aperture entrance that is spaced apart from the production location by a selected distance, that allows transport of at least a portion of the particles from the first chamber to the second chamber; and

providing a substantially constant magnetic field **B** in the first chamber, where the magnitude and direction of the magnetic field **B** are chosen so that (i) a trajectory in the field **B** of at least one target species particle produced at the production location will pass substantially through the aperture entrance and (ii) a trajectory in the field **B** for at least one charged non-target species particle produced at the production location will be no closer than a positive threshold distance from the aperture entrance,

whereby at least one of the target particles becomes chemically attached to at least one of the CNTs in the second chamber, and a density of the at least one non-target species adjacent to the aperture entrance is reduced relative to a density of the target species adjacent to the aperture entrance.

22. The method of claim 21, further comprising:

at a first selected time, providing a first vector value **B1** of said magnetic field **B** for which said corresponding trajectory in the magnetic field **B1** of a first target species is preferentially delivered to said particle aperture entrance; and

at a second selected time that is later than the first selected time, providing a second vector value **B2** of said magnetic field **B** for which said corresponding trajectory in the magnetic field **B2** of a second target species is preferentially delivered to said particle aperture entrance, where the magnitude of the field **B1** differs from the magnitude of the field **B2**.

23. The method of claim 21, further comprising configuring said particle communication mechanism so that transport of ultraviolet radiation from said first chamber to said second chamber is suppressed.

24. The method of claim 23, wherein said transport of said ultraviolet radiation from said first chamber to said second chamber is suppressed by providing an elongated aperture, having an aperture central axis and an aperture side wall and connecting said first and second chambers, further comprising arranging the aperture according to at least one of the following: (i) the aperture central axis is aligned off-axis so that little or no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, (ii) the aperture central axis is curvilinear, and is provided with sufficient curvature so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, and (iii) the aperture central axis has at least one bend point at which a direction of the central axis changes abruptly so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber.

25 The method of claim 24, further comprising providing at least a portion of said aperture side wall with a chemical substance (i) that absorbs said ultraviolet radiation and emits no radiation in response thereto or (ii) that absorbs said ultraviolet radiation and, in response thereto, emits radiation having an emitted energy that is lower than required to cause a bond breakage in at least one of a carbon-carbon bond and a carbon-hydrogen bond.

26. The method of claim 21, further comprising choosing the target particles from a group of target particle species consisting of H, Li, Na, K, Rb, Cs, F, Cl, Br, I, dichlorocarbene, C_nH_{2n}, C_nH_{2n+1} and C_nH_{2n+2}, with n = 1, 2 and 3.

27. The method of claim 21, wherein said step of irradiating said precursor gas comprises irradiating said precursor gas with at least one of a dc source, a radiofrequency source, a microwave source and an induction source of radiation to provide a cold plasma.

28. The method of claim 21, further comprising choosing said pressure p1 in a range 100 μm Hg $\leq$ p1 $\leq$ 1000 μm Hg.

29. The method of claim 21, further comprising choosing said pressure p2 in a range 1 μm Hg $\leq$ p2 $\leq$ 10 μm Hg.

30. The method of claim 21, further comprising allowing at least one of said target particles to become chemically attached to at least one of said CNTs in said second chamber in an exposure time interval no longer than about 30 sec.

31. The method of claim 21, further comprising allowing said at least one target particle to become chemically attached to said at least one CNT at a temperature in said second chamber that is no greater than about room temperature.

32. A system for functionalizing a collection of carbon nanotubes (CNTs), the system comprising:

a first chamber having a plurality of precursor particles at a selected production location at a first selected sub-Torr pressure p1, where at least one charged non-target species is present in the first chamber;

a radiation source for irradiating the precursor gas at a production location to provide a plurality of charged target species particles, and to provide a preferred initial velocity for at least one target species particle;

a substrate, located in a second chamber and having a collection of CNTs thereon, where the second chamber has a second selected sub-Torr pressure p2 and where p2 is not more than about p1/100;

a particle communication mechanism, having a particle aperture entrance that is spaced apart from the production location by a selected distance, that allows transport of at least a portion of the particles from the first chamber to the second chamber; and

a magnetic field source that provides a substantially constant magnetic field **B** in the first chamber, where the magnitude and direction of the magnetic field **B** are chosen so that (i) a trajectory in the field **B** of at least one target species particle produced at the production location will pass substantially through the aperture entrance and (ii) a trajectory in the field **B** for at least one non-target species particle produced at the production location will be no closer than a positive threshold distance from the aperture entrance,

whereby at least one of the target particles becomes chemically attached to at least one of the CNTs in the second chamber, and a density of the at least one non-target species adjacent to the aperture entrance is reduced relative to a density of the target species adjacent to the aperture entrance.

33. The system of claim 32, wherein:

at a first selected time, a first vector value **B1** of said magnetic field **B** is provided for which said corresponding trajectory in the magnetic field **B1** of a first target species is preferentially delivered to said particle communication mechanism; and

at a second selected time that is later than the first selected time, a second vector value **B2** of said magnetic field **B** is provided for which said corresponding trajectory in the magnetic field **B2** of a second target species is preferentially delivered to said particle communication mechanism, where the magnitude of the field **B1** differs from the magnitude of the field **B2**.

34. The system of claim 32, wherein said particle communication mechanism is configured so that transport of ultraviolet radiation from said first chamber to said second chamber is suppressed.

35. The system of claim 34, wherein said transport of said ultraviolet radiation from said first chamber to said second chamber is suppressed by providing an elongated aperture, having an aperture central axis and an aperture side wall and connecting said first and second chambers, and the aperture is configured according to at least one of the following: (i) the aperture central axis is aligned off-axis so that little or no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, (ii) the aperture central axis is curvilinear, and is provided with sufficient curvature so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber, and (iii) the aperture central axis has at least one bend point at which a direction of the central axis changes abruptly so that substantially no ultraviolet radiation that is produced within said first chamber can move in a single straight line from said first chamber to said second chamber.

36 The system of claim 35, wherein at least a portion of said aperture side wall is provided with a chemical substance (i) that absorbs said ultraviolet radiation and emits no radiation in response thereto or (ii) that absorbs said ultraviolet radiation and, in response thereto, emits radiation having an emitted energy that is lower than required to cause a bond breakage in at least one of a carbon-carbon bond and a carbon-hydrogen bond.

37. The system of claim 36, wherein said target particles are chosen from a group of target particle species consisting of H, Li, Na, K, Rb, Cs, F, Cl, Br, I, dichlorocarbene, C_nH_{2n}, C_nH_{2n+1} and C_nH_{2n+2}, with n = 1, 2 and 3.

38. The system of claim 32, wherein said radiation source for irradiating said precursor gas is at least one of a dc source, a radiofrequency source, a microwave source and an induction source of radiation to provide a cold plasma.

39. The system of claim 32, wherein said pressure p1 lies in a range 100 μm Hg $\le$ p1 $\le$ 1000 μm Hg.

40. The system of claim 32, wherein said pressure p2 lies in a range 1 μm Hg $\le$ p2 $\le$ 10 μm Hg.

41. The system of claim 32, wherein at least one of said target particles becomes chemically attached to at least one of said CNTs in said second chamber in an exposure time interval no longer than about 30 sec.

42. The system of claim 32, where said at least one target particle becomes chemically attached to said at least one CNT at a temperature in said second chamber that is no greater than about room temperature.